Name____________________________________ Section______________ Date_______________

Lab Partner______________________________________

Lab Report: Visible Hydrogen Spectrum and its Interpretation

Part 1: Energy Levels in the Bohr Hydrogen Atom

In this section we will calculate energies for orbits (energy levels) of the Bohr hydrogen atom using the following relationship:

$$E = -2.178 \times 10^{-18} J \left(\frac{1}{n^2}\right)$$

where $\boldsymbol{E}$ is the energy (in joules) and $\boldsymbol{n}$ is the electron energy level. Allowable values for $\boldsymbol{n}$ are are non-zero, positive integers (1, 2, 3,….∞).

Instructions: For each value of n, calculate the energy of the orbit in joules. Please show your work for the calculations for n = 1, 2 and ∞. Answer the questions that follow.

n = 1________________

n = 2________________

n = 3________________

n = 4________________

n = 5________________

n = 6________________

n = ∞_______________

1) Which value of n yields the lowest energy? n = ______________ what is its energy? _______________

2) Which value of n yields the greatest energy? n = ______________ what is its energy? _______________

3) Are the energies *increasing* or *decreasing* as n becomes larger? _________________

Briefly explain your answer:

Using the energies you calculated above you can calculate the change in energy of an electron ($\Delta E_{electron}$) that drops from one energy (E_i) level to another (E_f).

4) What operation would you perform to find the change in energy? $\Delta E_{electron}$ = ___________________

5) What is $\Delta E_{electron}$ for the transition n = 2 → 1? _______________________

When an electron drops from one energy level to another a photon with some amount of energy (E_{photon}) is released.

6) What will the energy of this photon be equivalent to? E_{photon} = ___________________

7) What is E_{photon} if an electron undergoes a transition from n = 2 → 1? ________________________

Briefly explain how the magnitude and sign of your answers for question 5 and 7 compare:

Part 2: Calculation of Wavelengths in the Lyman, Balmer and Paschen Transition Series

In this section we will use the Rydberg equation, which often has the following form:

$$\frac{1}{\lambda} = \mathcal{R}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

where $\frac{1}{\lambda}$ is the inverse of the wavelength (also called the wavenumber) of the photon that is given off during an electron transition ($\frac{1}{\lambda}$ is sometimes referred to as the wavenumber), $\mathcal{R}$ is the Rydberg constant (1.097×10^7 m^{-1}) and n_1 and n_2 are the lower (final) and higher (initial) energy levels, respectively.

Instructions: For each value of n, calculate the wavelength (in nm) of the photon that is given off during the indicated transitions. Please show your work for the calculation for n = 2 → 1. Answer the questions that follow. (note: all of these transitions are part of the *Lyman series*)

n = 2 → 1___________________

n = 3 → 1___________________

n = 4 → 1___________________

n = 5 → 1___________________

n = 6 → 1___________________

8) Are any of these wavelengths in the visible region? _______________

9) What region of the electromagnetic spectrum are any non-visible wavelengths in? _________________

10) Using the following equation:

$$E = \frac{hc}{\lambda}$$

what is the energy of the photon with the wavelength you calculated for n = 2 → 1 using the Rydberg equation? _____________________

Briefly explain how this value compares to your answer from question 7 in Part 1 above:

Instructions: For each value of n, calculate the wavelength (in nm) of the photon that is given off during the following transitions. Please show your work for the calculation for n = 3 → 2. Answer the questions that follow. (note: all of these transitions are part of the *Balmer series*)

n = 3 → 2___________________

n = 4 → 2___________________

n = 5 → 2___________________

n = 6 → 2___________________

n = 7 → 2___________________

n = 8 → 2___________________

Are any of these wavelengths in the visible region?

What region of the electromagnetic spectrum are any non-visible wavelengths in? ___________________

Instructions: For each value of n, calculate the wavelength (in nm) of the photon that is given off during the following transitions. Please show your work for the calculation for n = 4 → 3. Answer the questions that follow. (note: all of these transitions are part of the *Paschen series*)

n = 4 → 3___________________

n = 5 → 3___________________

n = 6 → 3___________________

n = 7 → 3___________________

Are any of these wavelengths in the visible region?_______________

What region of the electromagnetic spectrum are any non-visible wavelengths in? ___________________

Part 3: Comparison of Calculated and Observed Hydrogen Spectrum

In this section we will compare the calculated values for the hydrogen visible spectrum with the wavelengths we observed in lab using the spectrometer.

Calculated values (any between 400 and 700 nm):

Wavelength (nm):___________________

Wavelength (nm):___________________

Wavelength (nm):___________________

Wavelength (nm):___________________

Observed values:

Wavelength (nm):___________________

Wavelength (nm):___________________

Wavelength (nm):___________________

Wavelength (nm):___________________

If you observed wavelengths that you did not predict based on your calculations, what could be the reason for this observation? Was there any other source of light in the room?

Report the percent error for each wavelength you observed:

Calculated	Observed	Percent error
______ nm	______ nm	____________
______ nm	______ nm	____________
______ nm	______ nm	____________
______ nm	______ nm	____________

Briefly explain how your observations compare to your calculated values:

Part 4: Comparison to modern theory

It is important to remember that, although the Bohr model of the atom was a major step forward in the understanding of electronic structure, it had flaws and ultimately gave way to the modern 'full' quantum mechanical description. Like the Bohr model, the modern model of electronic structure predicts the spectral lines of hydrogen and hydrogen-like atoms that contain a single electron; however, unlike the Bohr model, modern theory can also be applied to multi-electron atoms.

1) What differences exist between the two models and what major flaw is built-in to the Bohr model of the atom?

2) What similarities exist between the two models?

3) Draw a diagram of the Bohr hydrogen atom (up to n = 3) in the space below.

Bohr Model of Hydrogen

4) Draw the energy level diagrams (up to n = 3) predicted by modern quantum theory for a single electron atom (such as hydrogen) and a polyelectronic atom (such as neon).

Single electron atom	Polyelectronic atom

5) How could the second diagram help explain the complexity of the spectra you obtained for elements other than hydrogen? Briefly explain.